REMOTE VIBRATION DIAGNOSTICS OF TECHNOLOGICAL EQUIPMENT OF METAL-ROLLING DEPARTMENT

ДИСТАНЦИОННАЯ ВИБРАЦИОННАЯ ДИАГНОСТИКА ТЕХНОЛОГИЧЕСКОГО ОБОРУДОВАНИЯ МЕТАЛОПРОКАТНОГО СТАНА

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Abstract: *The methods of remote vibration diagnostics realization of metal-rolling department's equipment will be considered in the article, and also the example of the really set system is resulted. Application of this system allows not only exposing the state of workings parts of mechanism presently, but also carrying out the prognosis of equipment's working capacity.*

Keywords: *MONITORING, SENSOR, VIBRATION DIAGNOSTICS, DIRECT SPECTRUM, ENVELOPE SPECTRUM*

1. Introduction

Modern industry development produces the promoted requirements to rotating machinery reliability. Therefore on most industrial enterprises, possessing some park of rotating equipment the vibration monitoring and diagnostics systems are implemented. Different firms can make these systems, which could have different configuration, but task for them one is looking after a working equipment, to expose the already present defects of rotation units (basically rolling bearings and journal bearings), and also to make the equipment capacity prediction.

Machines and equipment condition monitoring is one of the most effective methods to decline accident rate and increase technical systems reliability. For the rotating equipment vibration monitoring is very important, because in the process of condition irreversible change there always is a chain of defects and even one of them really changes the equipment vibration background.

The monitoring and diagnostics systems can be both stationary and portable. Functionally these systems do not differ practically. A difference is only in mobility. Application of these systems is gives another very important advantage: due to these systems, equipment repair conducted now on the real condition only.

Thus, in order that equipment always was under supervision it is necessary to produce the equipment with the already specified sensors fastening places of the vibration monitoring and diagnostics systems. Reliable fastening of sensors, assembling and disassembling simplicity, and also outer influence defense them must be concerning the industrial rotating equipment producers.

2. Nature of rolling bearing's vibration

Rolling bearing's work in high-speed pump composition and at presence faults in it can influence on a vibration and modulating it processes with the followings fundamental frequencies:

- Rotation frequency of movable ring in relation to immobile: f_{rot} ;
- Rotation frequency of separator in relation to an outer ring:

$$f_r = \frac{1}{2}\cdot f_{rot}\cdot\left(1-\frac{d_{sr}}{d_r}\cdot\cos(\alpha)\right); \quad (1)$$

Where: d_{sr} - solid of revolution diameter;

$d_r \approx \frac{1}{2}(d_{out}-d_{in})$ - Diameter of separator;

d_{out} - Diameter of outer ring;

d_{in} - Diameter of inner ring;

α - contact angle of bodies and rolling paths;

- Rolling frequency of solid of revolution on an outer ring:

$$f_{out} = \frac{1}{2}\cdot f_{rot}\left(1-\frac{d_{sr}}{d_r}\cdot\cos(\alpha)\right)\cdot z = f_r\cdot z; \quad (2)$$

Where: z - solids of revolution number;

- Rolling frequency of solid of revolution on an inner ring:

$$f_{in} = \frac{1}{2}\cdot f_{rot}\left(1+\frac{d_{sr}}{d_r}\cdot\cos(\alpha)\right)\cdot z = (f_{rot}-f_r)\cdot z; \quad (3)$$

- Rolling frequency of solids of revolution in relation to the surface of rings:

$$f_{sr} = \frac{1}{2}\cdot f_{rot}\cdot\frac{d_r}{d_{sr}}\left(1-\frac{d_{sr}^2}{d_r^2}\cdot\cos^2(\alpha)\right); \quad (4)$$

Expressions (Eq.1, Eq.2, Eq.3, and Eq.4) are evaluating only basic harmonics frequencies in the vibration spectrums and envelope of its high-frequency components at the different types of defects [1].

3. Industrial vibration monitoring and diagnostics systems.

In world industry is used the enormous amount the rotating equipment vibration monitoring and diagnostics systems of different firms.

2.1. Stationary systems.

The stationary monitoring system is needed above all things for a multimode strength equipment, guided an auxiliary personnel. Exactly personnel errors is more frequent than all are the defects multiplying reason of the guided equipment, which it must find out practically instantly (for a few turns of rotor) for failure timely prevention.

On Figure 1 the simplified structure of the vibration monitoring and diagnostics stationary system is shown.

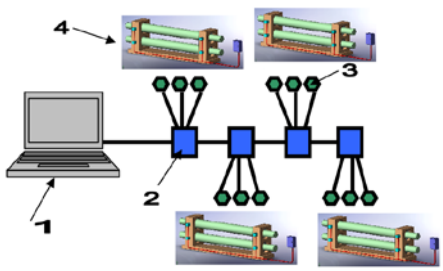

Figure1 *Structure of the vibration monitoring and diagnostics stationary system.*

1 - The computer with special software; **2** - The Signals transformation card in digital form; **3** - Vibration sensors; **4** – Supervising equipment.

2.2. Portable systems.

Equally with the stationary systems wide application is found the portable monitoring and diagnostics systems (Fig. 2), equipped by expert or automatic troubleshooting routines. These systems can be divided into two basic classes are the extended monitoring systems, including with the expert programs, it means, that diagnostics is executed by the prepared expert, and mass diagnostic systems with the standard rotating equipment automatic condition diagnostic and prediction programs. Such system consists of:

- A portable device (devices), providing vibration measuring and analysis in heavy industrial terms;
- Computer with the program of monitoring, containing a database and fulfilling operations row of signals analysis and processing of analysis results;
- Expert or automatic diagnostic program, processing obtained diagnostic information.

Figure 2. Vibration portable set on the vibration analyzer СД-12М base, produced by company BACT (Russia) [2]

4. *Design of equipment with the monitoring system sensors fastening places.*

All diagnostic equipment listed above has different sensors in the complete set, it are:

- Piezoelectric vibration acceleration transformers (accelerometer);
- Optical (lasers) vibration speed transformers;
- Eddy currents transformers of the relative movement (proximeters);
- Optical or eddy currents revolution sensors.

The more reliable the monitoring and diagnostics system sensor is set, the more precisely parameters taken off and the high-quality working capacity diagnosis for supervised units. Therefore it is very important to produce industrial equipment with the already prepared places for monitoring systems sensors fastening. It can be as screw-threads holes for the stationary system sensors permanent setting as milled places for the portable system sensors temporal mounting by magnets.

5. *The system of remote vibration monitoring and diagnostics.*

This current system of vibration monitoring and subsequent analysis of the signals is set in one of the steel mills. For example, the system installed on the double shaft, which is necessary for transmitting rotation from the gearbox to the working stand. The system consists of the following components (Fig. 3):

1. Controlled equipment (double shaft);
2. The point of installation of the vibration sensor №1;
3. The point of installation of the vibration sensor №2;
4. The point of installation of the vibration sensor №4;
5. The point of installation of the vibration sensor №3;
6. The connecting cables in the protective shell;
7. Block for information reading or conversion.

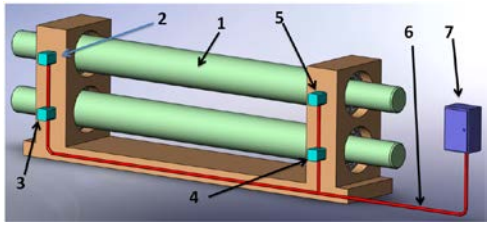

Figure 3. *The scheme of vibration monitoring system installed on a double shaft.*

Also, the system can be done in two ways:

1. Information reading made by the operator by means of a portable data collector, and then analyzed on a computer. Connecting the collector is made in block established remotely;
2. Information reading is made remotely using a wireless device for reading, conversion and sending information.

The information that comes from the sensors is processed by a special program, or an operator manually compare information obtained on different days, and concludes on the state of the equipment.

The following are comparison examples of direct spectrum (Fig. 4) and the envelope spectrum (Fig. 5) obtained on different days, from the sensor in 1 point.

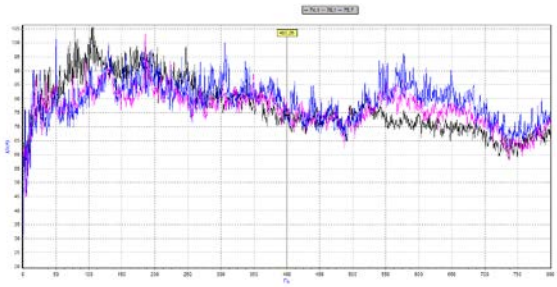

Figure 5. *Direct spectrum – (dB(A)),* $F_b = 800Hz$ *, Spectrum lines: 1600, Average: 8, measured at point 1 on different days.*

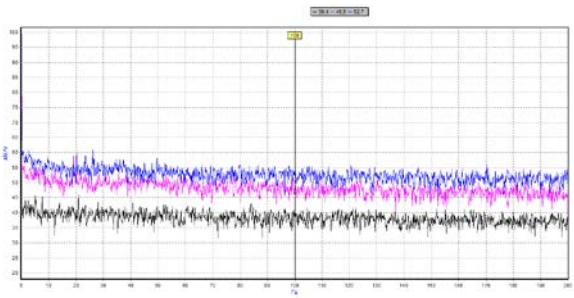

Figure 6. *Envelope spectrum – (dB(A)),* $F_b = 200Hz$ *, Band-pass filter* $F_a = 3200Hz$ *Spectrum lines: 1600, Average: 8, measured at point 1 on different days.*

As seen from Fig.5 and Fig.6, vibration levels over time tend to increase. From this we can judge the state of the equipment and make predictions of its working capacity.

Conclusions

Vibration diagnostics of metallurgical or any rotating equipment is very important. This makes it possible to significantly reduce the costs of the equipment, to extend the term of its operation, as well as improve the quality of products. The company must have a diagnostic service that provides vibration monitoring and forecasting the state of the equipment. It is also necessary to establish the system of remote monitoring equipment. The cost of equipment and software for the diagnosis is usually recouped within a year at its regular use.

Literature

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[2] http://www.vibrotek.ru/russian/